TELEMETRY:
Comments and Suggestions from the Coastal Grizzly Project 1983

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INTRODUCTION

Central to the objectives of the Coastal Grizzly Project is the locating of collared grizzly bears to determine habitat use.

The basic method of locating collared animals involves travelling to known stations and pointing an antenna at the strongest signal. From these data, it is possible to triangulate and determine animal location. However, if this was the extent of the process, it would indeed be simple. Many factors influence the signals strength and directionality and affect the accuracy and precision of the telemetry. For accurate telemetry, the influences of weather, topography, vegetation, and distance must be considered.

EQUIPMENT

The system used in the Coastal Grizzly Project was centred around a 4-element Yagi antenna and a gyro compass (both mounted in a truck) and a scanning Telonics receiver.

The truck-mounted antenna required little maintenance, although some points were checked periodically. The elements (cross pieces) on the antenna were subject to loosening and the Allen screws holding them in position were checked and tightened if necessary. In addition, the correct spacing and centering of the elements should be available and checked occasionally.

The co-axial cable and the fittings were subject to wear and eventual failure, particularly at the junction of the cable and the connector (Bendix). These were repaired or replaced easily with wire cutters, pliers, and a soldering iron. I recommend that the female tip be soldered to ensure a good contact. Failure of the cable or connectors could result in an erratic signal reception sometimes similar to that received from a moving animal. Also excessive twisting in the antenna cable should be avoided to prevent the shielding from breaking or kinking.

The antenna shaft required regular cleaning and lubricating. Occasional cleaning of the shaft with a wash-polish removed any build-up of dirt which impeded its movement. I used a good brass cleaner. After many trials, the lubricant, WD-40 applied regularly, provided a smooth contact surface. Other lubricants should be tested (e.g. silicon and graphite).

In general, the truck could be driven with the antenna at half-height with no damage. At full height, the antenna, at high speeds or on rough roads, rotated inducing unnecessary wear. At slower speeds, the antenna could be left at full height with no adverse effects.

During periods of dry weather (if they occur) the shaft tended to collect dust and dirt which impeded its movement. The best solution was to drive with

the antenna lowered and increase the lubrication. Forcing the shaft resulted in scoring on its surface creating greater difficulty in movement.

The receiver required little maintenance although care was exercised to ensure it had an adequate charge, stayed dry, and was not roughly treated.

A Telonics digital data processor was also available for use in conjunction with the receiver. The processor was of little use under most conditions as the variability of the signal from the animal was often greater than or equal to the variation from moving the antenna. It was used occasionally for stationary animals to delineate a range of equal signal strength; however, when it was used successfully, the results only confirmed what the ear had detected.

A hand-held 4-element Yagi antenna was used for a short period during the summer. There appeared to be little difference in the overall performance between the two methods. The truck-mounted antenna had the benefit of being quicker, slightly more precise, and easier to use. However, the hand-held antenna allowed for greater selection of locations for telemetry. To be able to stand on banks, stumps, or rocks to obtain the extra height that seems crucial to good telemetry was often an asset. For night telemetry and foul weather, the truck-mounted antenna was far superior.

The truck-mounted gyro compass was used to align the truck along a known bearing. The accuracy of the gyro was checked frequently to ensure that it had not strayed from true north by using stakes driven into the ground along the cardinal bearings, lining the truck up, and checking the gyro. Another means was by sighting down the antenna when it was set at North (using the gyro) and checking against a hand-held compass pointed at a distant object.

The gyro compass was affected by the positioning of metal bodies nearby. If the driver's door was open while taking readings, the needle of the gyro moved approximately two degrees towards the door.

The gyro compass had a response time before settling on the true bearing, therefore overcompensation in lining up the truck was common. For this reason, I recommend that slight changes in position should be followed by sufficient time for the gyro to settle.

TELEMETRY

THE PROCESS

The first step in locating a collared bear was a general reconnaissance, usually starting near the area of the last fix and travelling toward the animal. It was pointless and time consuming to attempt to take a bearing on an animal too far away. Once the bear was roughly located, by using signal strength and directionality, an accurate bearing could be taken.

Personal preference usually dictated the technique used to take a bearing. I preferred to set the tone fairly low and use a moderate volume in such a combination that the headphone speaker distorted slightly, producing a distinctive clicking noise at the end of each beep. This only occurred when the

signal was at its loudest. By adjusting the volume and tone controls, it was usually possible to obtain a signal that only distorted over a narrow range (40-60°). The next step determined the size of the range (between which two bearings did the headphones distort). Halfway between the limits should be the strongest signal. The volume and tone were re-adjusted so that the signal distorted over a smaller range (10-20°) and the centre again noted. The new centre roughly corresponded to the previous one. This process was repeated until the signal peak was located to within two or three degrees. Once a bearing had been determined, the above process was to ensure its precision and accuracy.

This method worked well for animals in relatively open areas where the signal was symmetrical. If the signal was asymmetrical (i. e. being affected by bounce), this method could be very inaccurate.

Another method similar to the one described above involved using a high-pitched signal and a low volume. By adjusting these two variables. the signal could only be heard over a very narrow range. The process then became a matter of bisecting the range, re-adjusting the volume, and continuing until a repeatable bearing was obtained.

The final method was the simplest: the antenna was scanned over the range of the loudest signal and, by locating the peak several times, a good bearing could be made.

Regardless of the method used, the locator had to scan the whole 360° range when first arriving at a position. It was not uncommon for several small signal peaks to exist and by not checking for the loudest peak, erroneous data resulted.

If the collared animals were extremely close, it was often possible to hear the signal with only a pencil for an antenna or nothing at all. When a bear was this close, it was often possible to hear branches breaking or see movement. In this situation, the location was marked with flagging and a bearing to the activity was recorded; in this way, an accurate location was made.

Once a bearing had been taken, regardless of the method used, the process was repeated at the next station until a minimum of three bearings, preferably four or five, were obtained.

The next step involved drawing out the bearings on a 1:20 000 composite photo to determine if they made any sense (i.e. would close). If all bearings pointed to the same area, I ran the data through the Kimsquit Polygon Program. If two or three bearings pointed to the same location and one or more appeared aberrant, the best option was to return to the positions from whence the "bad" bearings came and check them. Once all or most of the bearings indicated that the animal had been found, I proceeded with the analysis.

At the time the fix was taken, it was important to record an associated error angle to give the proper error polygon. The value of the error angle was not altered without rechecking the bearing. It was often difficult to determine the correct error angle to use, but, in general, 5° for a high confidence bearing and 8° for less confident ones seemed to work well. Any error angle less than 4° was beyond the accuracy of the equipment or greater than 10° was too inaccurate.

If the resultant error polygon appeared to be inaccurate, bearings were rechecked or additional ones were taken. If multiple closures were possible, depending on the bearings used (Fig. 1), the best option was to recheck the bearings in question to determine the accurate bearings.

CHOICE OF POSITIONS

Selecting the correct position (location from which a bearing is taken) was essentially a matter of trial and error until experience determined which positions yielded accurate information. In general, the objective was to bound the animal from below, directly opposite, and above. If these objectives were obtained, the accuracy was greatly increased, but they were largely dependent upon the location of the collared animal in relation to the available positions.

The amount of information obtained from a bearing varied depending on the positions used. If, as often happens, the bearing from one station was directed through that of another, little information was obtained because the bearings should be the same or close to it. However, if a bearing was in doubt, this type of position increased the confidence in a given bearing. The choice of positions was dependent upon the situation.

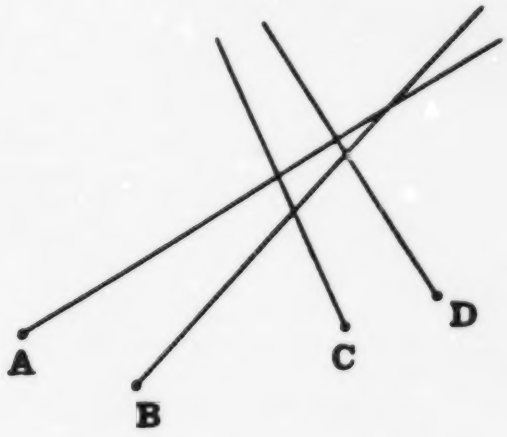

Fig. 1. An example of multiple closures.

Often a good means of determining the optimum position for the next bearing was to sketch the bearings already taken to see what positions would help close the error polygon. The first priority was to obtain those bearings that yielded the most information; other positions giving less were visited afterwards.

When positioning the truck to take a bearing, it was often advantageous to locate the vehicle away from the marked position (e.g. 10 m or so), particularly if an object such as a large tree was directly in the line-of-sight of the bearing. By moving the truck a short distance, the accuracy increased.

MOVING ANIMALS

A moving collared animal should be on fast pulse rate; however, if the bear was moving slowly or on even terrain, the collar sometimes remained on slow pulse rate. For this reason, the signal variability was often a better measure of animal activity.

The difficulty in locating moving bears was two-fold. First, the signal varied in intensity as the animal moved making it difficult, if not impossible, to determine if the change in signal strength was the result of moving the antenna or the moving bear. The best means to locate the animal was to scan for the peak signal several times to obtain the best estimate. Second, the resultant fix might not truly indicate the bear's position, especially if the animal was moving quickly and not remaining in any one area for any length of time. The resultant fix placed the animal either closer to or farther from the locator depending on the path of the vehicle with respect to the bear's movement (Fig. 2).

The net result of these two factors was inaccurate telemetry. The only means by which the error could be reduced was to move quickly between stations and obtain the necessary bearings as rapidly as possible. The problem became a matter of two counteracting forces: the difficulty and time required to obtain an accurate bearing increased, while the time between bearings had to be decreased.

Overall, an animal moving from one area to another produced little in terms of accurate telemetry. However, if an animal was moving about in the same general area, it was often possible to produce a good fix.

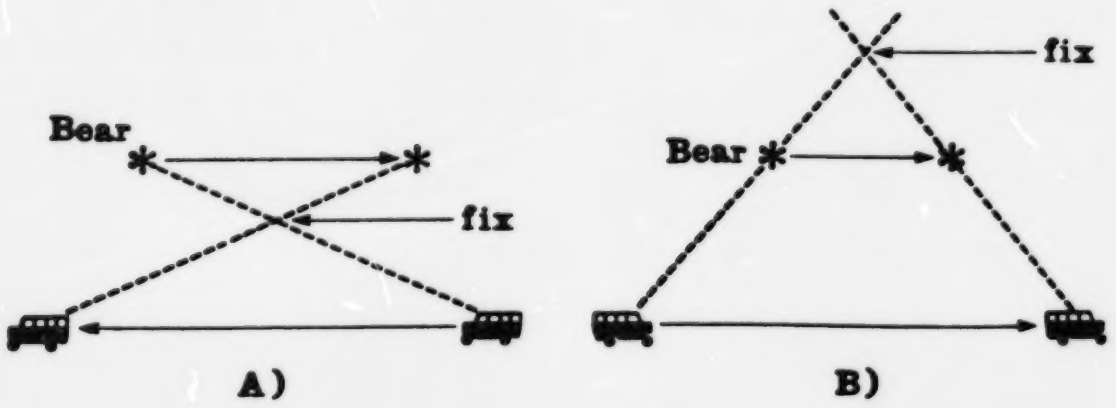

Fig. 2. Two-fold difficulties in locating moving bears:
A. A change in signal strength could be caused either by the vehicle moving or by the bear moving.
B. A fix might give a false position if the bear was moving quickly.

PROBLEMS AND POSSIBLE SOLUTIONS

While trying to locate bears in the Kimsquit Valley, many variables had to be considered. The foremost problems were telemetry "shadows" - areas where accurate telemetry could not be obtained - and signal bounce.

Telemetry shadows were caused by a combination of factors: distance, weather, topography, and vegetation density. As distance increased, the signal strength decreased often to a point where it could not be heard. When the effects of topography and vegetation were added, the result was the loss or distortion of the signal.

Bounced signal was a common form of signal distortion. The signal from the collar was reflected off rock walls or slides and was bounced to the antenna. Often the bounced signal was considerably stronger than the direct signal because the direct signal travelled its whole length through heavy vegetation, while the bounced signal travelled through open air above the vegetation bouncing off rock and arriving at the antenna much stronger.

Often it was impossible to determine a bounced signal from a direct one. However, I devised a few tricks that could sometimes aid in defining the true bearing. The first of these involved driving and monitoring the signal at the same time. A bounced signal seemed to be strongest only at certain locations, a movement of only a few metres made a large difference in signal strength and directionality. By driving with the antenna up, it was possible to test a variety of areas quickly. If it appeared as though the signal only peaked in the occasional spot or varied greatly in directionality, the signal was most likely bounce.

A bounced signal often yielded a "plateau" of signal that lacked a definite peak common in a direct signal. Another, but more time consuming, means of determining if a signal was bounce involved actually recording the bearing from many stations and if the bearings did not show any pattern, concluding that the bearings, or some of them, were bounce or a combination of bounce and the true signal.

Great care was taken to distinguish between true bearings and bounce as it was common for bearings taken on bounce to close and often with small error polygons.

Using the general topography of an area also aided in determining a bounce signal from the true one. In areas where two or more signal peaks existed, and one of them was not from a rock wall, cliff, or slide, it was probable that the one in the open was correct. However, the bounced signal affected where the peak of the true signal occurred. For this reason, ignoring the bounced signal often did not work as the two signals overlapped. The best policy was often to move to another position where there was no bounce.

Bounce was eliminated or greatly reduced by either increasing the elevation of the antenna or by positioning the truck in areas where the true signal travelled through as little material (e.g. vegetation) as possible. In both instances, the result was an increase in the signal strength of the direct signal such that the effects of the bounced signal were eliminated or reduced.

Occasionally an area known to produce bounce would produce a precise fix. The reason for this was unclear but perhaps was linked to the location of the bear, the orientation of the collar, and the micro-topography (e.g. an elevated area).

The effects of vegetation were made clear on windy days. The result was often seen as a variable signal from a stationary transmitter (i.e. test collar). This can influence the locator's ability to discern the true signal's direction. However, it did not produce the same degree of variation created by a moving animal. The effects of vegetation were noticeably decreased in October as many species in the shrub layer had lost their leaves. Rain in general only caused a small increase in the amount of bounce from cliffs and slides.

Topography influenced the ability to do accurate telemetry. When bears were moving in rough terrain such as in the Kimsquit Valley where many small stream channels exist, the result was a widely fluctuating signal strength. There was no way to compensate for this type of signal and it was often impossible to obtain a good bearing. The only option was to wait for the bear to become stationary or move into a less variable habitat. In general, rough terrain and great distances yielded the lowest accuracy of all telemetry.

The effects of topography were often profound. Many times an animal had been located with great accuracy only to find that the fix seemed to place the animal too close for the signal strength (volume) being received. The best option was to recheck the bearings. Often when bears dug deep daybeds, the signal could be greatly reduced and the fix was indeed correct.

When bears were bedded down against a rock, tree, or bank, the directionality of the signal could be greatly influenced and it was often difficult to determine when this happened. The telemetry accuracy was usually only slightly affected.

Fig. 3. Signal behaviour on the side hills.

When bears were on the side hills on either side of the valley, the signal was usually very loud as there was little vegetation to interfere. A line-of-sight signal resulted. Animals on the side hills could give accurate telemetry but also gave a washed-out or 360° signal which could not yield a bearing. If the animals were on the west side of the road, fairly high up the slope, the positions were too close for accurate telemetry because the line-of-sight was through the hill itself (Fig. 3) and a bounce signal may be stronger. To test for animals up the slopes, the vehicle was positioned far from the hill up or down the valley to give a rough idea of the bear's location.

When animals were up the side valleys (Hoam, Pollard, Cornice, and Robson), it was very difficult, if not impossible, to locate them accurately as the signal bounced off the valley walls. To locate animals when up side valleys, positions at the road crossing the creek or up the side spurs were used. Again using positions far away up or down the valley were also used to determine if the animals were up in these areas. General comments on the positions used can be found in Appendix A.

CHANGES TO THE ANTENNA AND TRUCK

In general, the system worked very well. However, a few minor changes could aid in the efficiency of the telemetry.

My first suggestion is that the notch, used for securing the antenna in a lowered position, be enlarged to facilitate easier and quicker location. If the sloping sides of the notch were increased, it would aid in antenna positioning.

The compass rose used to determine bearings has an inner and outer ring. Often people unfamiliar with the system had trouble remembering which to use; therefore, it may be easier to remove the outer ring and simplify the process.

The height of the antenna seemed to pose no problems in use at the current height. However, as height is a basic factor in determining the precision and accuracy of telemetry, it may be advantageous to increase the shaft length an extra half metre or so.

The only additions needed for the truck are a backup light, a dash-mounted lamp for more efficient night telemetry, and a spotting lamp to identify bears on or near the road at night.

Other useful pieces of equipment would be a soldering iron, wire cutters, and spare co-axial connectors (i.e. connecting tips) so that the antenna co-axials can be repaired easily.

CHANGES TO THE PROGRAM

The Kimsquit Polygon Program used in the Coastal Grizzly Study functioned very well in general. A few minor modifications would aid in its effectiveness.

The first problem, while not serious, may raise doubt in suspecting minds. Using only one bearing, the program was not only able to locate an animal but also give a four-sided error polygon. The program should be corrected to give an error message when only one bearing is entered or remains after other bearings have been deleted.

If on data input, an error is made and the "enter" key is used to advance the program on the "Data OK" statement, the program assigns values to each piece of data. It would be more expedient if when data that should be entered are not (e.g. "Position #"), the program automatically goes to the correcting statement to avoid errors.

When the input data are presented to the user for verification, prior to the correcting statement, it would be more useful to show the position number rather than the Universal Transverse Mercator coordinates. The UTM's are not necessary. More important would be a printout of the error angle used at each station.

The next point is again for the matter of convenience. When entering the data, modifications would be easier if the lines "Eliminate last bearing?" and "Add new bearing?" were replaced by a line such as "Replace bearing #__." Thus, any bearing could be changed rather than just the last.

The next point deals with accuracy and precision. Many times, bearings were taken resulting in a good fix only to drive further up the road to discover that the animal was in a totally different location. The problem was that bearings created by signal bounce can close. The program cannot discern accurate bearings that are precise from inaccurate bearings that are also precise, but the user should be aware that it can occur.

Further on this same topic is the manner in which the error polygon is calculated. Again, there appears to be nothing wrong with the technique, but the implications of interpreting the data without considering the factors of accuracy and precision are severe. Figure 4 shows a fix that is imprecise (the bearings do not cross at a point). Figure 5 on the other hand is very precise. The resulting error polygon of the two fixes is shaded and show that the less precise fix shows a higher degree of accuracy than the second which is in fact more precise. The degree to which this occurs in the field is unclear but it does happen. The implications are that fixes which have a very small error polygon are sometimes taken as being more accurate than they really are. There is nothing that can be done to correct this as the program output is only as good as the data input, but the user should regard the error polygon only as a rough estimate. Drawing the bearings out to scale helps in recognizing the accuracy of a fix.

Another area that might be considered as an addition to the program is a system by which the type of signal being received when the animal was located could be recorded. A five number system (see below) which could be combined would help in recording the activity and therefore the type of sign the field person should expect.

e.g. 1 - slow
2 - fast
3 - steady
4 - variable
5 - very

therefore, 13 - slow-steady
1324 - slow-steady-fast variable
245 - fast-very variable

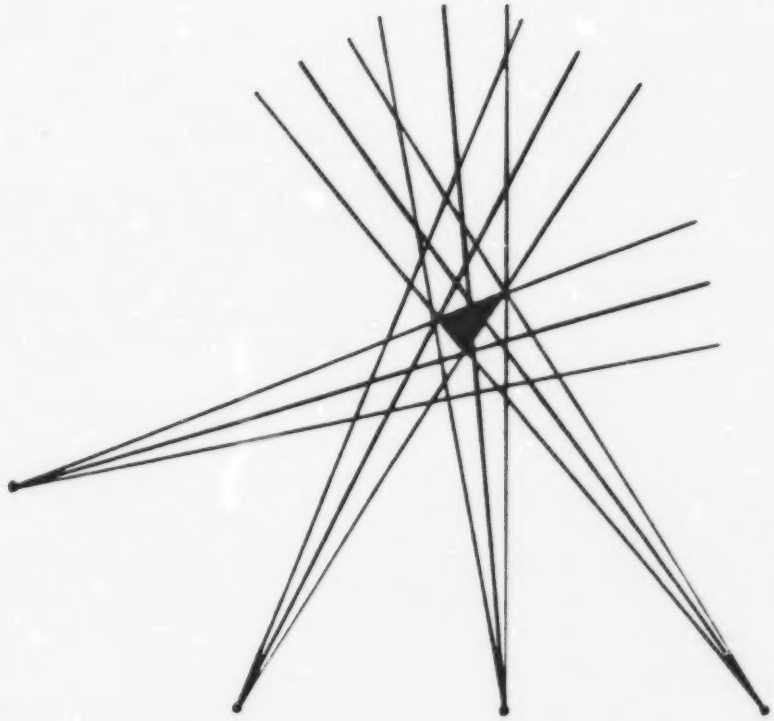

Fig. 4. An imprecise fix with high accuracy for the error polygon.

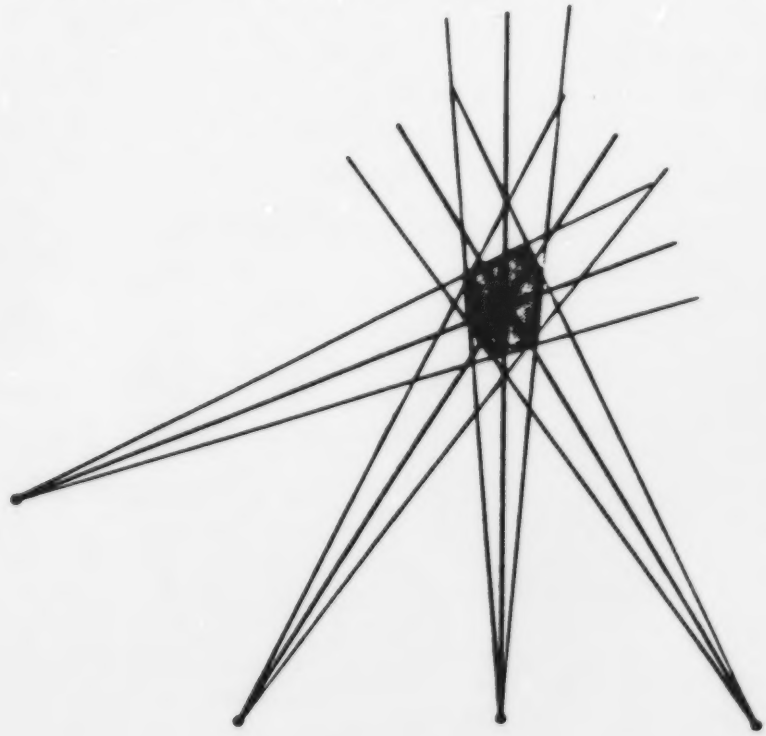

Fig. 5. A precise fix with lower accuracy for the error polygon.

The final suggestion, again minor, is that the data could be input in two lines rather than four as a matter of convenience. The error angle and the position number could be input together as could the antenna bearing and gyro heading. When hundreds of trials are done, any time saver helps.

RECOMMENDATIONS

1. A new person, before going out to locate bears, must be adequately trained by those who know the system best. The test telemetry should be continued and the locator given ample practice. Working with stationary beacons and test collars is nothing like working with a collared bear but enough similarities exist to make it worthwhile for practice.

2. When doing test telemetry, the collar should be placed at bear height and wrapped around a log or tree. An open collar appears to radiate a different signal pattern.

3. Towers, constructed at set locations, may overcome telemetry shadows and bounce, major problems in the Kimsquit Valley. Elevation seems to be a key to good telemetry. If towers are constructed, they must be located within easy access of the road to reduce the amount of time between bearings for reasons given elsewhere. The location of these towers should be as close to those areas where the bounce or shadows exist, namely the area near lower Snake. The exact locations should be chosen only after extensive experimentation.
   For those areas where the towers cannot obtain accurate signals, it may be possible to use either a hand-held Yagi and a reliable boat or towers located on the river. Bears, however, can be disturbed by the boat motor. Many times when the boat went by the location of a bear, rapid and distant movement or activity changes were noted. The combination of towers and river access would probably yield the best system. The truck mounted Yagi, however, will most likely remain the central tool. There are areas that will never yield accurate telemetry (e.g. behind Knob Hill) unless a very extensive network of towers is constructed. Another problem arises because of the layout of the Kimsquit Valley. There is only one main-line along the west side which means that much of the area is fairly distant from the antennas. If the towers were set up near the road, accurate telemetry would still be difficult since accuracy decreases with distance.

4. To aid accurate telemetry, the gyro bias and its correction factor must be determined. The gyro error should be accounted for but was not in 1983.

5. All position numbers should be well marked to aid visitors and people helping with telemetry.

CONCLUSIONS

The telemetry system in the Coastal Grizzly Project was fair in its overall performance. Unless accuracy can be increased and obtained for all areas, bias may result in the overall habitat analysis. The degree to which the telemetry locations obtained in 1983 can be used for habitat analysis, if not ground

truthed, may be questionable as many variables influence the accuracy and it was known that some fixes were inaccurate.

Changes to the system in 1984 should help remedy the situation and increase the efficiency significantly, aiding in meeting the objectives of the project.

Appendix A. Positions - General Comments

Position No.

1	- very good for animals at estuary and somewhat higher
2,3,4,5	- good for the estuary, airstrip area and lower river
6,7	- used very little, proximity of equipment affects signal - fair for animals behind camp
36	- good for animals from estuary to below position 14
9,10,14	- good for both sides of road from west wall almost to the river, prone to bounce
15,16,11	- used little as bears did not frequent areas near the road here - probable telemetry "shadow" at river, east of these positions - good for bears on middle Snake
12	- very subject to bounce from backwall - positioning of truck affects bearings significantly - often good as fourth bearing for animals on middle Snake area - occasionally of use for animals closer to river, but this area is another probable telemetry shadow
17,37,13	- very good for animals on either side of road - used very often - appears accurate east to Knife Channel - beyond suspect - bounce can be a problem with animals on upper Knife
42,33,43	- good for upper Snake, Knife, Fingerling Island, lower Railway, Teabag and lower Amazon - usually obtain directional signal - for bears near east wall accuracy decreases significantly
41	- same as above, except limited for areas south
34,39	- very good - used very often for animals from Teabag to Cottonwood I. - elevation and openness yield good precision and accuracy
35	- limited to Cottonwood I. and sometimes West Channel
47,50	- good for Pollard I., south to West Channel - watch for bounce on west wall for animals just east of position 35
40	- very good for lower Pollard, Pollard I. Caroluck's camp, Cottonwood I. and upper Amazon
52,53	- good for lower Pollard Cr. area
18	- used little, fair for lower Pollard and sometimes Caroluck's camp
19	- good when trying to roughly locate bears - accurate and precise for lower Pollard and Caroluck's - good for testing if bears are up Pollard Valley

22	- only accurate for animals from the road to the river - signal is channeled up the creek for animals deep between Cornice and Pollard Cr.
32,49,51	- better than position 22 - good for animals east of road, south of Cornice and north of cutback #2 - signal weak but directional for animals near river
23,24,25	- good for areas near mouth of Cornice
26	- excellent station to monitor for other collared animals - good for mouth of Cornice and south about half way to Pollard - good for roughly locating bears in the middle valley
27	- poor station - severely affected by antenna position - sometimes fair for bears below cutblock #6
48	- good for animals below cutblock #6
29,30,31,44	- good for animals near Robson Cr. - used infrequently
45	- never used in 1983.

Wildlife Working Reports should not be cited because of the preliminary nature of the data contained within.

WR-1 Progress report - coastal grizzly research project: Year 1. A.N. Hamilton. October 1984. 43pp. (Also printed as WHR-9)

WR-2 Progress report - coastal grizzly research project: Year 2. A.N. Hamilton and W.R. Archibald. October 1984. 27pp. (Also printed as WHR-10)

WR-3 Telemetry: Comments and suggestions from the coastal grizzly project 1983. A.E. Derocher. October 1984. 14pp. (Also printed as WHR-11)

WR-4 Habitat types of the Kimsquit River estuary. C. Clement. October 1984. 27pp. (Also printed as WHR-12)

WR-5 Biogeoclimatic units and ecosystem associations of the Kimsquit drainage. C. Clement. October 1984. 89pp. (Also printed as WHR-13)

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